

APPLICATION FOR UNITED STATES LETTERS PATENT

for

Well Screen Primary Tube Gravel Pack Method

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Well Screen Primary Tube Gravel Pack Method

Background of the Invention.

1. Technical Field

The present invention relates to the gravel packing of wells and in more particular relates to an apparatus for delivering a particulate-laden fluid and providing a distribution of the fluid at different levels within the wellbore annulus being packed.

2. Background

In producing hydrocarbons or the like from loosely or unconsolidated and/or fractured subterranean formations, it is not uncommon to produce large volumes of particulate matter (e.g. sand) in conjunction with the formation fluids. As is known in the art, these particles routinely cause a variety of problems that result in added expense and increased downtime. Accordingly, it is extremely important to control the production of these particulates in most operations.

Probably the most common technique for controlling the production of particulates (e.g. sand) from a well is one that is known as “gravel packing”. In a typical gravel pack completion, a well screen is lowered into the wellbore and positioned across the interval of the well that is to be completed. Particulate material, collectively referred to as gravel, is then pumped as a slurry down the tubing on which the screen is suspended. The slurry exits the tubing above the screen through a “crossover” tool or the like and flows downward in the annulus formed between the screen and the well casing or open hole, as the case may be.

The liquid in the slurry flows into the formation and/or the openings in the screen that are sized to prevent the gravel from flowing through them. This results in the gravel being bridged on or “screened out” on the screen and in the annulus around the screen where it collects to form the gravel pack. The gravel is sized so that it forms a permeable mass which blocks the flow of any particulates produced with the formation fluids.

One of the main problems with gravel packing, especially where long horizontal or inclined intervals are to be completed, is obtaining equal distribution of the gravel along the entire completion interval, i.e. completely packing the annulus between the screen and the casing in cased hole completions or between the screen and the wellbore in open hole completions. Poor distribution of the gravel (i.e. incomplete packing of the interval resulting in voids/unpacked areas in the gravel pack) is often caused by the dehydration of the gravel slurry into more permeable portions of the formation interval that, in turn, causes the formation of gravel “bridges” in the annulus before all of the gravel has been placed. These bridges block further flow of the slurry through the annulus causing insufficient placement of the gravel. Subsequently, the portion of the screen that is not covered or packed with gravel is thereby left exposed to erosion by the solids in the produced fluids or gas and/or that portion of the screen is then easily blocked or “plugged” by formation particulates (i.e. sand).

Use of tubes on the outside of the screen has been widely used as an alternate path for solids laden fluid in gravel packing or frac packing around a downhole well screen. There is no recorded use of these tubes as the primary path or source for gravel packing.

U.S. Pat. No. 4,945,991, Jones, L. G. , “Methods for Gravel Packing Wells” discloses a method for gravel packing a well and thereby preventing incomplete gravel packing due to the formation of sand bridges in the annulus to be packed. It uses a screen with rectangular perforated shunt tubes attached to the outside of a screen longitudinally over the entire length of the screen. In this method, the perforated shunts (i.e. flow conduits) extend along the length of the screen and are in fluid communication with the gravel slurry as it enters the annulus in the wellbore adjacent the screen. It is claimed that the shunts can be used to pump the gravel slurry into the annulus with no description of how this can be done.

U.S. Pat. No. 5,333,688 discloses a method and apparatus for gravel packing a gravel pack screen or plurality of screens having shunt tubes positioned within the base pipe of the screen where they do not increase the overall diameter of the screen. Gravel slurry is distributed or carried by these shunt tubes to different points or levels of a wellbore annulus around the screen through the spaced outlets through the housing; i.e. from an internal passage within the apparatus, thereby protecting the passage from damage during operation. The plurality of gravel screen units are connected together at the lower end of a workstring. However, by placing the shunt tubes within the base pipe (i.e. ultimately part of the production flowpath), an intricate and sophisticated valve is required to each of the outlets after the gravel packing operation is completed, thereby adding substantially to the costs of the screen and of installation. As well, with the shunt tubes in the production flowpath any remedial or production data gathering work will be inhibited by the tubes and will cause such work to be expensive or incapable of being performed.

If a sand bridge forms in the annulus formed by the screen and the wellbore prior to placing all of the gravel, the gravel slurry will flow through the conduits past the sand bridge(s) and out into the annulus through the perforations spaced along the conduits to complete the filling of the annulus above and/or below the bridge(s). U.S. Pat. No. 5,113,935 is a further modification of this type of well screen. In some instances, valve- like devices are provided for the perforations in these conduits so that there is no flow of slurry through the conduits until a bridge is actually formed in the annulus; see also U.S. Pat. No. 5,082,052.

U.S. Pat. No. 5,113,935 discloses apparatus for gravel packing a wellbore interval having shunt means (i.e. conduits) on the external surface of a sand screen which can selectively deliver a gravel slurry to different levels of the interval during operation. The shunt means is comprised of a variety of differently configured, perforated conduits and/or arrangements of these conduits.

In many prior art, references for alternate path well screens, the individual perforated conduits or shunts are shown as being preferably carried externally on the outside surface of the screen;

see U. S. Pat. Nos. 4,945,991; 5,082,052; 5,113,935; 5,417,284; and 5,419,394. This positioning of the shunt tubes has worked in a large number of applications, however, these externally-mounted perforated shunts are not only exposed to possible damage during installation but, more importantly, effectively increase the overall diameter of the screen. The latter is extremely important when the screen is to be run in a small diameter wellbore where even fractions of an inch in the effective diameter of the screen may make the screen unusable or at least difficult to install in the well. Also, it is extremely difficult and time consuming to connect respective shunt tubes attached to the outside of the screen to shunt tubes attached to the outside of the following screen in the course of assembling the screen and lowering it into the wellbore.

U.S. Pat. No. 5,082,052 discloses a sand screen positioned in a well adjacent an oil or gas reservoir to be produced. At least one conduit is in juxtaposition with the sand screen and has passageways at selected intervals to establish fluid communication between the conduit and the annulus of the well surrounding the sand screen. A gravel packing slurry is injected down the well to form a gravel pack in the annulus. Actuatable devices associated with the conduit passageways control fluid flow between the conduit and annulus so that if the gravel portion of the slurry forms a bridge in the annulus, thereby blocking slurry flow through the annulus, the slurry will be diverted from the annulus into the conduit through one or more of the passageways in the conduit above the bridge, downward through the conduit and out through one or more passageways in the conduit into the annulus below the bridge to continue the forming of the gravel pack in the annulus.

U.S. Pat. No. 5,419,394 discloses a well tool for delivering fluid (e.g. sand or gravel slurry) to different levels within a wellbore which is comprised of a delivery conduit which, in turn, has a plurality of exit ports spaced along its length. Each exit port has an exit tube connected thereto. Each exit tube includes a portion whose length lies substantially parallel to the longitudinal axis of the delivery conduit which permits larger exit ports to be used which, in turn, substantially reduces the likelihood of an exit port becoming blocked prior to completion of a well operation.

In order to keep the effective diameter of a screen as small as possible, external perforated shunt tubes are typically formed from “flat” rectangular tubing even though it is well recognized that it is easier and substantially less expensive to manufacture a round tube and that a round tube has a substantially greater and more uniform burst strength than does a comparable rectangular tube.

An additional disadvantage to mounting the shunt tubes externally, whether they are round or rectangular, is that the shunt tubes are thereby exposed to damage during assembly and installation of the screen. If the shunt tube is crimped during installation or bursts under pressure during operation, it becomes ineffective in delivering the gravel to all levels of the completion interval and may result in the incomplete packing of the interval. One proposal for protecting these shunt tubes is to place them inside the outer surface of the screen; see U.S. Pat. Nos. 5,476,143 and 5,515,915. However, because these prior art, alternate path well screens incorporate the perforated shunts and require that holes be drilled in the wire wound portions of the screen and/or the shunt tubes, some additional form of seal between the drilled hole in the wire and shunt tube is needed to prevent slurry flow and possible erosion in the internal surface of the screen annulus formed with the base pipe. This substantially increases the cost of the screen without substantially decreasing the over all diameter of the screen. In addition, the connections between the joints of screen in these prior art well screens, require either a union type connection, which is understood by those skilled in the art, that is incapable of withstanding torque being applied, a timed connection to align all of the shunt tubes from screen joint to screen joint, a jumper shunt tube between screen joints or a cylindrical cover plate over the connection between screen joints that is either welded to the base pipe or held in place by metal bands. All of these alternatives are expensive, time consuming and/or very difficult to handle on the rig floor while making up and installing the well screens.

U.S. Pat. No. 5,515,915 discloses a well screen for use in gravel packing completions which produces a good distribution of gravel over the entire completion interval. The screen is comprised of a base pipe and an outer surface (e.g. wire wrap). A plurality of flow paths (e.g.

shunt tubes) are positioned in the annulus which is formed between the base pipe and the outer surface of the screen, thereby providing the necessary alternate flowpaths for the slurry without substantially increasing the overall, effective outside diameter of the screen.

Other downhole well tools have been proposed for fracturing a formation (U.S. Pat. No. 5,161,618) or treating a formation (U.S. Pat. No. 5,161,613) whereby individual conduits or shunt tubes are positioned internally within a housing or the like to deliver a particulate treating or fracturing fluid to selective levels within the wellbore. However, the outlets through the housing of these tools remain open after the particular operation is completed which would be detrimental in gravel packing completions since the produced fluids could then carry particulates back into the housing through these openings after the gravel pack has been completed and the well has been placed on production.

U.S. Pat. No. 5,161,618 discloses a method for producing multiple fractures by a single operation from a single wellbore which penetrates a fracture interval which, in turn, includes a plurality of zones which break-down under different fracturing pressures. Fracturing fluid is delivered from a workstring directly to different levels within a section of the wellbore which lies adjacent the fracture interval through a plurality of alternate paths which, in turn, lie substantially adjacent to the zones to be fractured.

Summary of the Invention.

This invention relates to a method for gravel packing a well that penetrates an unconsolidated or poorly consolidated subterranean oil or gas reservoir. The present invention method provides for distributing a solids laden fluid to different points of the wellbore annulus from a multiplicity of unperforated flow conduits or tubes positioned within the annulus formed between the base pipe and the outer surface of a screen. The tubes receive the solids laden fluid directly from the gravel pack cross-over tool and are connected via internal manifolds and exit nozzles on each joint, thereby providing the primary flowpaths for the solids laden fluid to be delivered to the annulus between the wellbore and the well screen. The flow tubes

are connected to exit nozzle chambers placed at different points along the exterior of the screen to allow for dispersion of the solids laden fluid around the complete circumference of the screen and along the entire length of the screen. Because the well screens have interior flow tubes with a direct fluid connection from the crossover tool, it is possible to pump down only the flow tubes and out the nozzles connected to the flow tubes to deliver the solids laden fluid to the wellbore annulus with the nozzles rather than having the majority of fluid falling down through the annulus as in the prior art with external shunt tubes.

In prior art, the well screen member is typically a wire wrapped screen member with a varying number of shunt tubes installed in the annulus between the wire wrapped screen and the wellbore. The tubes are the conduits that are attached the outside of the screen, perforated and spaced at various intervals along the screen. As known in the industry, the screen is lowered into a wellbore with washpipe and a crossover tool inside and connected to the packer and workstring. The packer above the screen is set and a gravel slurry is pumped through the workstring to the crossover tool that diverts the slurry flow to the well annulus surrounding the screen and the fluid returns to the surface via the washpipe and then up the workstring and wellbore annulus. The washpipe is needed to insure that the slurry doesn't dehydrate early and reaches the bottom of the screen. If a bridge forms in the annulus causing an incomplete pack, the slurry continues to flow to the shunt tubes and the gravel pack completed through the exit nozzles that are not occluded. After placing the well on production, attempts are made to either flow the mud cake back through the gravel pack or use chemicals to dissolve or break it down.

The present invention further provides an apparatus for gravel packing an interval of a wellbore wherein there is good distribution of gravel over the entire completion interval even if a sand bridge or void or the like is formed in the well annulus before the placement of the gravel is completed. The present apparatus is similar to that disclosed in U.S. Pat. No. 4,945,991 but includes unperforated shunt means (e.g. conduits and arrangement of conduits) positioned within the annulus formed between the base pipe and the outer surface of the screen that can directly deliver the gravel slurry to different levels of the interval during the

gravel pack operation without flow path change and needing no alternate route. This is believed to provide a more reliable means of deploying the apparatus in some applications (e.g. completion of long openhole intervals) over the prior art apparatus with the external shunts. Also, no washpipe is needed inside the screen of the present invention because the slurry does not go to the screen and wellbore annulus above the screen as in prior art. Because no washpipe is needed, make up time of the screen assembly is reduced and therefore reduces rig time and costs.

The present invention further provides for distributing the gravel slurry to different points of the wellbore annulus from a multiplicity of unperforated flow conduits or shunt tubes positioned within the annulus formed between the base pipe and the outer surface of the screen, thereby providing the necessary primary flowpaths for the slurry without substantially increasing the overall, outside diameter of the screen. The shunt tubes are connected to exit nozzle chambers placed at different points along the screen to allow for dispersion of the slurry around the complete circumference of the screen and along the entire length of the screen. The nozzle diameters may be altered from the top of the screen to the bottom of the screen to insure slurry placement.

Also, by placing the unperforated shunt tubes within the annulus formed between the base pipe and the outer surface of the screen, a) the shunt is protected from damage and abuse during handling and installation of the gravel pack screen; b) a more desirable “round” tube can be used to form the shunt tubes thereby providing shunts with greater burst strength and less chance of failure during operation than most external shunts; c) the ability is present to increase the number of shunts and thereby provide more flow area for delivery of the gravel

slurry along the completion interval; and d) an externally smooth outside diameter on the outer surface of the screen is permitted to simplify the installation of the well screen

More specifically, the well screen of the present invention is comprised of a base pipe that has multiple openings through the wall thereof and an outer surface which is spaced from the base pipe to form an annulus between the base pipe and the outer surface. Typically, multiple alternate flow paths (e.g. shunt tubes) are spaced radially around the base pipe within the annulus and extended axially along the length of the base pipe and connected to exit nozzle chambers at designated intervals along the outer surface of the screen. Solid support members are interspersed between the shunt tubes to aid in supporting and spacing the outer surface away from the base pipe.

The outer surface of the screen is comprised of a continuous length of wire wrapped around the radially spaced shunt tubes and the support members and is welded at each point of contact with the tubes and support members. Each coil of the wrap wire is spaced slightly from the adjacent coils to form fluid passages between the respective coils of wire. End rings are used to align the tubes and support members and none of the tubes or support members are welded to the base pipe. This eliminates problems associated with stress crack corrosion due to welding dissimilar metals. Multiple exit nozzle chambers are provided at designated intervals along the outer surface of the screen and the shunt tubes are connected to the exit nozzle chambers by a connector above and below. The present well screen may consist of only one section or it may consist of multiple sections that are connected together via a manifolded connector.

The manifolded connector allows for ease of make up of the joints of screen as it is run in the wellbore. The connector has multiple holes bored through the length of the box and pin ends. As the pin end is made up into an adjacent box end, there is a manifold area or space (e.g. common area) above the make up point that combines the flow from all of the shunt tubes. No other tie-in of the shunt tubes or additional cylindrical cover plates are required; therefore the make up is similar to conventional pipe or tubing make up as performed in daily operations. The top of the manifold area is sealed with a seal ring above and below. A slotted plate can be positioned on the box end of the connector to allow for return of the slurry fluid to aid dehydration across the manifolded connector. No special tools or timed connection or welding in the area of the connector are needed or required. The joints are made up end to end without any interruption in the flow between the joints. An additional concentric sleeve is provided below the box end of the connector to provide an area for hanging the screen on slips and/or latching the rig elevators to pickup the screen joint. Slotting of the concentric sleeve can be to provide additional area for return of the slurry fluid to aid dehydration across the concentric sleeve area. These areas for return of the slurry fluid help achieve an even leak off rate across the entire well screen assembly. The top joint of the sand screen incorporates perforations in the base pipe member of the concentric sleeve to provide the means for pumping slurry into the primary flowpaths.

In the present invention method, solids laden fluids are pumped from the surface down the drill string or tubing to the crossover tool installed below the packer and attached to the top of the well screen. The concentric annulus formed in the top of the wellscreen and fluidly

connected to the flow tubes has the inner pipe perforated so as to allow for communication from the crossover tool to the concentric annulus. Circulation is then through the workstring to the crossover tool into the concentric annulus, through the tubes, positioned in the annulus between the wire wrapped screen and the base pipe, to the exit nozzles on the exterior of the wellscreen.

By delivering the solids laden fluid directly via the flow tubes, the fluid cannot dehydrate until it exits the nozzles at which time the solids laden fluid is at the desired location and then leaks off into the formation or back through the well screen. This better insures a more complete and controlled gravel placement across the entire reservoir interval regardless of the reservoir permeability contrasts or interval length. Therefore, in the present invention a wash pipe inner string, as known by those knowledgeable in the art, is not required or needed for insuring that the slurry reaches the bottom of the well. Also to insure that the slurry is delivered to the bottom nozzles, the size or diameter of the nozzles may be altered from the top of the screen to the bottom in order to choke back or diminish flow to the upper nozzles. In the event that a bridge forms early in the upper portion of the annulus formed by the well and the well screen, the larger nozzles will also aid in delivering slurry to the bottom portion of the screen.

The main purpose of the current invention method is to lower completion time by utilizing the tubes and nozzles and thereby lowers the cost of the well completion. Also, because there is no wash pipe run inside of the screen assembly, running time of the wellscreen is reduced, thereby reducing the cost of the completion due to less rig time for placement of the wellscreen.

Brief Description of Drawings.

The apparent advantages and improvements of the present invention method, as well as, operation will be better comprehended by referring to the drawings that are not necessarily to scale and in which like parts are identified with like numerals and in which:

Fig. 1 is an elevational view, partly in cut away, of the well screen of the present invention in an operable position within a wellbore;

Fig.1A is an elevational view, partly in cut away, of the well screen, having a slotted plate on the threaded box end for leak off, of the present invention in an operable position within a wellbore;

Fig. 2 is a partly section view of a single joint of the well screen of the present invention as set up to run in a wellbore;

Fig. 2A is a partly section view of a single joint of the well screen, having a slotted plate on the threaded box end for leak off, of the present invention as set up to run in a wellbore;

Fig.3 is a partly section view of a joint of the well screen of the present invention with several cross-sections taken along different lines of the well screen as indicated by the letters;

Fig.3A is a cross-sectional view of Fig. 3 taken along section lines AA of Fig 3;

Fig.3B is a cross-sectional view of Fig. 3 taken along section lines BB of Fig 3;

Fig.3C is a cross-sectional view of Fig. 3 taken along section lines CC of Fig 3;

Fig.3D is a cross-sectional view of Fig. 3 taken along section lines DD of Fig 3;

Fig.3E is a cross-sectional view of Fig. 3 taken along section lines EE of Fig 3;

Fig.3.1 is a partly section view of a joint of the well screen, having a slotted plate on the threaded box end for leak off, of the present invention with several cross-sections taken along different lines of the well screen as indicated by the letters;

Fig.3.1A is a cross-sectional view of Fig. 3.1 taken along section lines AA of Fig 3.1;

Fig.3.1B is a cross-sectional view of Fig. 3.1 taken along section lines BB of Fig 3.1;

Fig.3.1C is a cross-sectional view of Fig. 3.1 taken along section lines CC of Fig 3.1;

Fig.3.1D is a cross-sectional view of Fig. 3.1 taken along section lines DD of Fig 3.1;

Fig.3.1E is a cross-sectional view of Fig. 3.1 taken along section lines EE of Fig 3.1;

Fig. 4 is an enlarged sectional view, partly cut away, of the manifolded connector end portions of two adjacent joints of the well screen of Fig.1;

Fig. 4A is an enlarged sectional view, partly cut away, of the manifolded connector end portions, having a slotted plate on the threaded box end for leak off, of two adjacent joints of the well screen of Fig.1A;

Fig. 5 is a side view of the entire screen assembly in place in the wellbore and indicating the fluid flow while in the packer setting position;

Fig. 6 is a side view of the entire screen assembly in place in the wellbore and indicating the fluid flow while in the gravel packing position;

Fig. 7 is a side view of the entire screen assembly in place in the wellbore and indicating the fluid flow while in the gravel packing position with a sand bridge formed in the annulus; and

Fig. 8 is a side view of the entire screen assembly in place in the wellbore and indicating the fluid flow while in the reverse position.

Description of Preferred Embodiments.

In general, the present invention provides a method for gravel packing around a downhole well screen in an oil, gas or water well for what is known in the industry as a gravel pack completion. This method is a use of existing equipment that is used in gravel packing oil, gas and water wells. The existing equipment, however is used to circulate or squeeze a fluid containing sand or gravel into the annulus between the well screen and the open or cased hole, pumping a solids laden fluid directly into the annulus. In the present invention a gravel/ frac pack operation in the annulus formed by the wellscreen and the wellbore is performed by pumping the solids laden fluid directly in to the flow tubes positioned in the annulus formed by the base pipe and the wrap wire whether or not a bridge is formed in the annulus.

Referring more particularly to the drawings, Fig. 1 and 1A, they illustrate the wellscreen **17** of the present invention in an operable position within the lower portion of a producing and/or injection well **20**. Well **20** has a wellbore **25** that extends from the surface (not shown) through an unconsolidated and/or fractured production and/or injection formation **22**. Even though well **20** is shown as a vertical, open hole well, it should be noted that the method presented herein is equally applicable for use in cased hole wells and/or completions as well as horizontal and/or deviated (inclined) wellbores as dictated by the situation.

As shown, wellbore **25** is cased with casing **24** and cement **23** with perforations to the top of formation **22** that is to be completed with a well screen **17**. Screen **17**, crossover tool **31** and packer **30** are run inside of casing **24** in the unset position, and are connected to the surface

via the tubing or workstring 32 and positioned across formation 22 forming an annulus 18 with formation 22 or casing 24.

Figs 1 - 8 provide views of the well screen 17 with shunt tubes 7 in the annulus between a base pipe 1 and wrap wire 33. However, because base pipe 1 is shown as having multiple perforations 14, it should be recognized that other types of base pipes, e.g. slotted pipe, etc., can be used in place of the perforated base pipe without departing from the present invention. One or more unperforated shunt tubes 7 (two shown) are spaced around the circumference of base pipe 1 and extend longitudinally along the length of the base pipe 1. Unperforated shunt tubes 7 (i.e. flow conduits) are shown as being circular in cross-section, but it should be understood that conduits having other cross-sections (e.g. rectangular) can be incorporated without departing from the present invention.

As shown in Figs 1 and 1A, outer surface 32 of screen 17 is comprised of a continuous length of wrap wire 33 that, in turn, may be cut to provide a “keystone” shape (not shown). Solid support rods or longitudinal rod wire 34 (three shown in Fig. 1) or the like – which are commonly used in prior art screens of this general type – are interspersed with and/or between shunt tubes 7 to aid in supporting and spacing outer surface 32 (wire 33 in the preferred embodiment) of screen 17 away from base pipe 1. Shunt tubes 7 may be used as the only spacers between the base pipe 1 and the wire 33 without departing from the present invention.

Wire 33 is wrapped around the radially-spaced shunt tubes 7 and the longitudinal support rods 34 (Shown in Figs 3E and 3.1E) on base pipe 1 and is normally welded at each point of contact with the tubes and wire rods. Each circumferential wrap of wire 33 is spaced slightly from the adjacent wraps to form passageways (e.g. slot openings) 5 between the respective wraps of wire. The wire is wrapped circumferentially in various lengths along the base pipe 1 and is shrink fit onto the base pipe 1 while covering the shunt tubes 7 and longitudinal support rods 34 forming the outer surface 32. Connector rings 16 are shrink fit onto the outer surface 32 of screen 17 and base pipe 1 to connect the outer surface 32 of screen 17 to the base pipe 1. This is basically the same process commonly used in the manufacture of wire-wrap screens that are commercially available, such as LINESLOT Screens, Reslink, Inc. Houston, Texas.

As shown in Figures 1, 1A, 2, 2A, 4 and 4A, a part of the outer surface 32 of screen 17 incorporates multiple exit nozzle chambers 6 spaced along the length of each screen joint 17, shrink fitted onto base pipe 1 and comprised of several nozzles 10 (Figs. 1-4A) that are connected to the unperforated shunt tubes 7 via connectors 9. The outer surface 32 of screen 17 is connected to the exit nozzle chambers 6 via connector rings 16 that are shrink fitted on to the screen 17 and exit nozzle chamber 6.

The preceding description of screen 17 indicates that it is constructed of a perforated base pipe 1 with a wire 33 or the like that is wrapped in closely spaced wraps to form a permeable liner, it will also be recognized by those skilled in the art that outer surface 32 may be formed from a slotted pipe, screen material, or the like, as long as it is permeable to fluids and impermeable to particulates. Accordingly, the "screen" or "wellscreen" as used throughout the present specification and claims is meant to be generic and to include and cover all types of those structures commonly used by the industry in gravel pack and frac pack operations which permit the flow of fluids through them while abating the flow of particulates (e.g. commercially available screens, slotted or perforated liners or pipes, screen pipes, prepacked or dual prepacked screens and/or liners or combinations thereof that are used in well completions of this general type) into which shunt tubes 7 can be incorporated inside the outer surface of the screen 17 as that are used in well completions of this general type disclosed in the present invention.

Additionally, screen 17 may comprise of only one joint (e.g. 30 foot section) and may be at a continuous length or it may comprise of a multiple number of joints connected together, including by subs or blank pipe sections. As an example, Fig. 4 illustrates a coupling 2 for joining two screen joints 2A and 2B together. Coupling 2 is comprised of a standard threaded box 2b and a threaded pin 2a. After the two joints have been joined and properly torqued a manifold area 13 is formed above the threaded connection by the extension 2d that is threaded onto box 2b. Manifold area 13 is connected to the shunt tubes 7 from joint 2A via the channels 12 bored through exit nozzle chamber 6 above the threaded pin 2a, and is in turn connected to the shunt tubes 7 from joint 2B via channels 15 bored in the threaded box 2b.

Incorporation of this manifold area 13 allows for make up of the joints 2A and 2B without having to align the shunt tubes on the adjoining joints. The bored channels 15 in the threaded box 2a connect or align with the concentric annulus 8 formed by the base pipe 1 and external concentric pipe 4 that is positioned between the top exit nozzle chamber 6 and the threaded box 2b (Fig 4).

As known by those skilled in the art, the inability to bleed off the fluid from the slurry across the coupling 2 may cause insufficient dehydration of the fluid from the gravel slurry to occur in this area and thereby an incomplete pack is performed. A nonpreferred embodiment of the present invention may incorporate area 3 for bleed off of the fluid from the slurry (Figs 1A, 2A, 3.1 and 4A). The bleed off area 3 in coupling 2 is formed by milling a groove 2c radially around the exterior of the threaded box 2b, then covering the groove 2c by a thin slotted cover plate 3a that is held in place by the extension 2d, made up to the outside of threaded box 2b (Fig 4A). Bored hole 2e connects to bored channel 3c to allow bleed off of the fluid to the base pipe 1 (Fig. 4A). The bleed off area 3 is used when there is significant blank area between screen areas to provide bleed off of fluid that may be entrained in such area.

In a typical gravel pack operation, screen 17 is lowered into wellbore 20 (Fig.1) on workstring 32 and is positioned across the formation 22. Ball 43 is pumped onto ball seat 42 and pressure is applied through ports 51 as is understood by those skilled in the art to set packer 30.

Packer 30 is carried on the exterior of the workstring 32 in the unset position until being used to isolate the formation 22 prior to the gravel pack operation.

In accordance with the present method of invention, well screen 17 has one or more shunt tubes 7 that are spaced radially around the base pipe 1 and in the annulus between base pipe 1 and the outer surface of the wire wrap 33 and are connected to the concentric annulus 8 extending vertically from just below the concentric annulus 8 to the lower end of the well screen 17. These shunt tubes are connected to a plurality of exit nozzle chambers 6 spaced along the length of each screen joint 17, shrink fitted onto base pipe 1 and comprised of several nozzles 10. To the bottom of the workstring, a crossover tool 31 is installed so as to

align the ports 31a in the crossover tool 31 with the ports 70 to the concentric annulus 8 and is isolated from circulation into the perforated base pipe 1.

The initial step of this method is employed, as the packer 30, crossover tool 31 and well screen 17 are run in the wellbore 25 (Fig. 1) on workstring 32 and is positioned across the formation 22. As a second step shown in Figs. 5, ball 43 is pumped onto ball seat 42, locking flow to the concentric annulus 8, shunt tubes 7 and nozzles 10, and applying pressure through ports 51 as is understood by those skilled in the art sets packer 30. Then the workstring 32 is released from the packer 30. As known by those skilled in the art, after the packer 30 is set, the workstring 32 can also be released by rotating the workstring 32. Once released, the workstring 32 and the crossover tool 31 are then pulled up to the gravel pack position, meaning that ports 31a in crossover tool 31 maintain alignment with the ports 70 to concentric annulus 8 (Fig. 6). A gravel slurry 56 is then pumped down the workstring 32 into cross-over tool 31 and out of outlet ports 31a in crossover tool 31 through ports 70 and into concentric annulus 8, into shunt tubes 7, through nozzles 10 and into annulus 18. All of the shunt tubes 7 are manifolded together by concentric annulus 8 that is formed by base pipe 1 and external concentric pipe 4 to receive the gravel slurry 56 via the concentric annulus 8 through the ports 70 in base pipe 1.

As the gravel slurry flows downward in shunt tubes 7 and out nozzles 10 into annulus 18 around the screen 17, it will likely dehydrate due to fluid loss to formation 22 and/or through screen 17. The fluid entering screen 17 will return to the surface through holes 14 in base pipe 1, up basepipe 1, passing through check valve 44 and through pipe 31b in cross-over tool 31 (Fig 6). As the fluid from gravel slurry 56 dehydrates on the screen 17 and/or the formation 22, gravel 57 carried in slurry 56 is deposited and collects in the annulus 18 to form the gravel pack. As is known in the art, if enough fluid is lost from slurry 56 before annulus 18 is filled, a gravel bridge 60 (Fig 7) will form across the nozzle and screen annulus 18 and block flow through annulus 18 and prevent further filling below bridge 60. If this occurs while using the present invention, gravel slurry 56 can continue to be pumped downward through the shunt tubes 7 and out the respective exit nozzles 10 by-passing gravel bridge 60

and completing the gravel pack. Because the slurry has no path for leak off of the fluid, the slurry remains undehydrated in the shunt tubes 7 and is pumped past the bridged nozzle.

After the gravel pack operation is completed, the workstring 32 and crossover tool 31 are pulled up to the reverse out position meaning that ports 31a in the crossover tool 31 are now positioned above packer 30 (Fig. 8) and then pulled out of wellbore 25.

Because many varying and different embodiments may be made within the scope of the inventive concept taught herein which may involve many modifications in embodiments herein detailed in accordance with the descriptive requirements of the law, it is to be understood that the details herein are to be interpreted as illustrative and not in a limiting sense.